# Observations and Origins of the North American Tropopause Aerosol Layer (NATAL) during SEAC4RS

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## Overview

Satellite observations from CALIOP and SAGE II have shown the presence of a recurring summertime aerosol layer in the upper troposphere, associated with the North American Monsoon (NAM) (Figure 1). This Tropopause Aerosol Layer (NATAL) extends from Mexico to the Eastern Paciic and the southern United States following the prevailing upper troposphere anticyclone. Improved understanding of the origin, composition, and evolution of UTLS aerosol layers were among the primary objectives of the SEAC4RS airborne mission.

We are using airborne lidar (e.g. DIAL-HSRL, CPL) observations, and space-borne CALIPSO data to characterize the optical properties, size, likely composition, and origin of the NATAL aerosols. We are exploring the relationship with trace gas components, e.g. CO and H2O, and cirrus clouds in the UTLS using satellite and airborne measurements. We use trajectory mapping, and GOES brightness temperatures to explore potential convective origins lof NATAL aerosols, and use 3-d chemical transport model products to provide spatial and temporal context for interpreting the SEAC4RS observations.

## NATAL origins:

NATAL aerosols are most likely associated with deep convection of aerosols and/or their precursors. Continental deep convection in easterly flow over the mountains of Northern Mexico was a daily occurrence during SEAC4RS. At the same time, wildfire activity in western states, agricultural burning in SEUS, and transpacific transport of smoke from Asia provided additional potential aerosol sources to the NAM.

## Forecasting during SEAC4RS:

During SEAC4RS, we provided daily " convective air mass" predictions, indicating air masses over North America likely to have experienced deep convection in previous days. We used cloud-top temperatures from GOES satellite to initialize air parcel trajectories. In addition, we provided maps of trajectory-mapped CALIPSO aerosol backscatter observations for the UTLS (Figure 2).

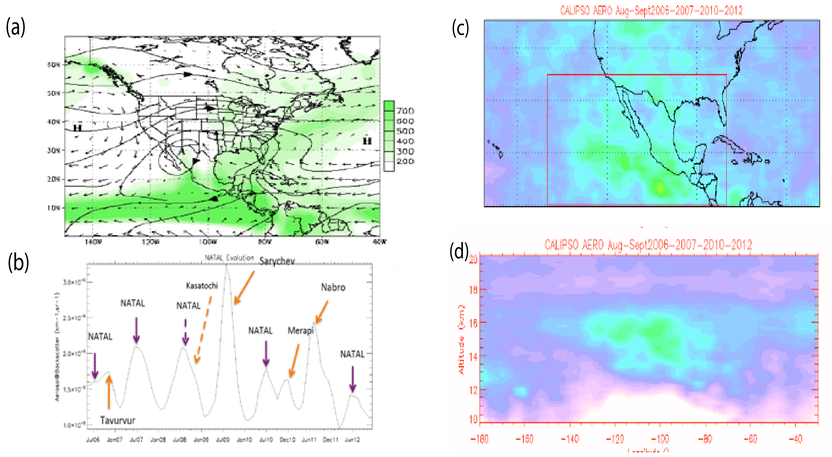


Figure 1: (a) Map of mean (July-Sept. 1979-1995) precip. (shaded, mm), 925 hPa wind vectors (ms-1) and 200 hPa geop. height (contours) shows the NAM upper tropospheric anticyclone; (b) Time series of CALIPSO aerosol backscatter (15- day mean) for region (red box, panel c) shows perenniel NATAL signal plus volcanic episodes. Natal aerosols associated with the NAM anti-cyclone evident in this map (c) and longitude cross-section (10-35 N) (d) of mean aerosol backscatter from CALIPSO between 15-17 km for Jul-Aug 2006-2007-2010-2012.

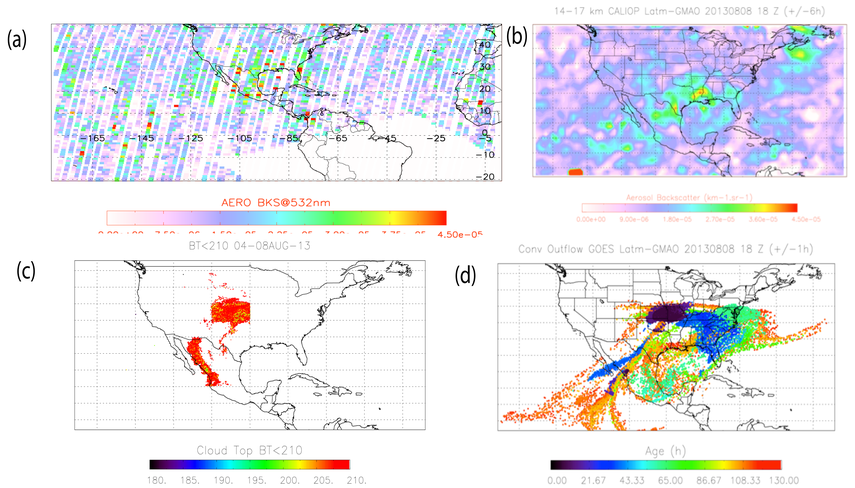


Figure 2: (a) Accumulated cloud-cleared mean aerosol backscatter at 532 nm between 14017 km obtained by CALIPSO from 30 July 2013 to 08 August 2013. (b) Snapshot of trajectory-mapped CALIPSO aerosol backscatter for 18Z, 8 August, 2013, between 14-17 km, (c) Accumulated convective pixels from GOES-W with BT<210 K between 04 and 08 August 2013. (d) Snapshot at 18 Z on 08 August 2013 of convective outflow age initialized from GOES-W observation of the last 4 days.

## Tracking UTLS aerosols observed on 8 August 2013 to deep convection:

Aerosol backscatter measurements from the DIAL-HSRL (panel a) aboard the DC8 show elevated aerosolbetween 14-17 km midflight. The RAQMS air quality model shows a layer of elevated aerosol in the same altitudes (panel b), and shows the flight track traversing an aerosol gradient in crossing the flank of the NAM anticyclone at 100 hPa (panel d). Back trajectories trace these aerosols to convective outflow over Northern Mexico (BTs < 220K) (panel c).

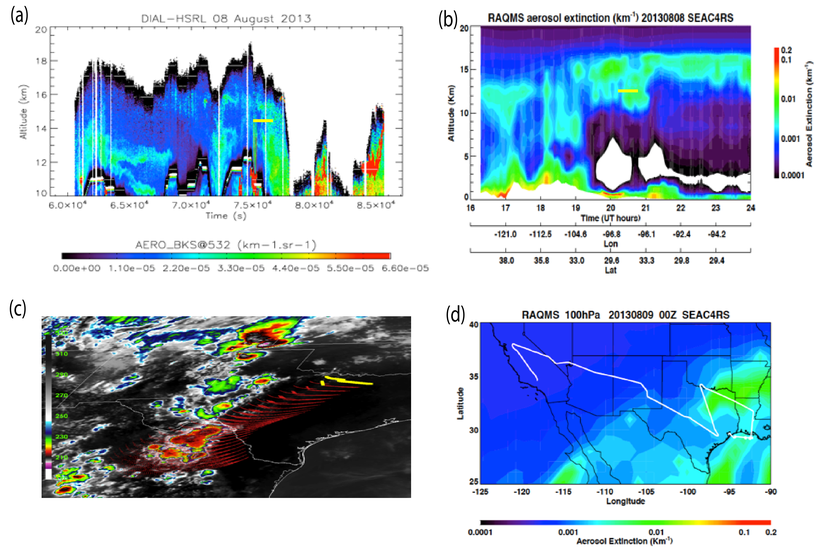


Figure 3: (a) Curtain of aerosol backscatter from NASA DIAL -HSRL along the transit flight of DC-8 Palmdale to Houston on 8 August 2008; (b) corresponding curtain of aerosol extinction from the RAQMS air quality model (model results courtesy Brad Pierce, NOAA). (c) GOES BTs at 23Z on August 8th, together with air parcel back trajectory tracks from highlighted NATAL layers (yellow bars in a and b); (d) map of aerosol extinction at 100 hPa from the RAQMS model, with DC8 flight track superimposed.

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